Fits and Tolerances

Grades of Tolerances IT1 to IT16

Grade		IT1	IT2	IT3	IT4	IT5	IT6	IT7	IT8	IT9	IT10	IT11	IT12	IT13	IT14	IT15	IT16
Number of units		Not stated				7i	10i	16i	25i	40i	64i	100i	160i	250i	400i	640i	1000i
Diameters mm		Tolerance μ, (μ = 0.001 mm)															
More than	Up to																
1	3	½	2	3	4	5	7	9	14	25	40	60	90	140	250	400	600
3	6	½	2	3	4	5	8	12	18	30	48	75	120	180	300	480	750
6	10	½	2	3	4	6	9	15	22	36	58	90	150	220	360	580	900
10	18	½	2	3	5	8	11	18	27	43	70	110	180	270	430	700	1100
18	30	½	2	4	6	9	13	21	33	52	84	130	210	330	520	840	1300
30	50	2	3	4	7	11	16	25	39	62	100	160	250	390	620	1000	1600
50	80	2	3	5	8	13	19	30	46	74	120	190	300	460	740	1200	1900
80	120	3	4	6	10	15	22	35	54	87	140	220	350	540	870	1400	2200
120	180	4	5	8	12	18	25	40	63	100	160	250	400	630	1000	1600	2500
180	250	5	7	10	14	20	29	46	72	115	185	290	460	720	1150	1850	2900
250	315	6	8	12	16	23	32	52	81	130	210	320	520	810	1300	2100	3200
315	400	7	9	13	18	25	36	57	89	140	230	360	570	890	1400	2300	3600
400	500	8	10	15	20	27	40	63	97	155	250	400	630	970	1550	2500	4000

Tolerance unit $i = 0.45 \sqrt[3]{D} + 0.001 D$, where

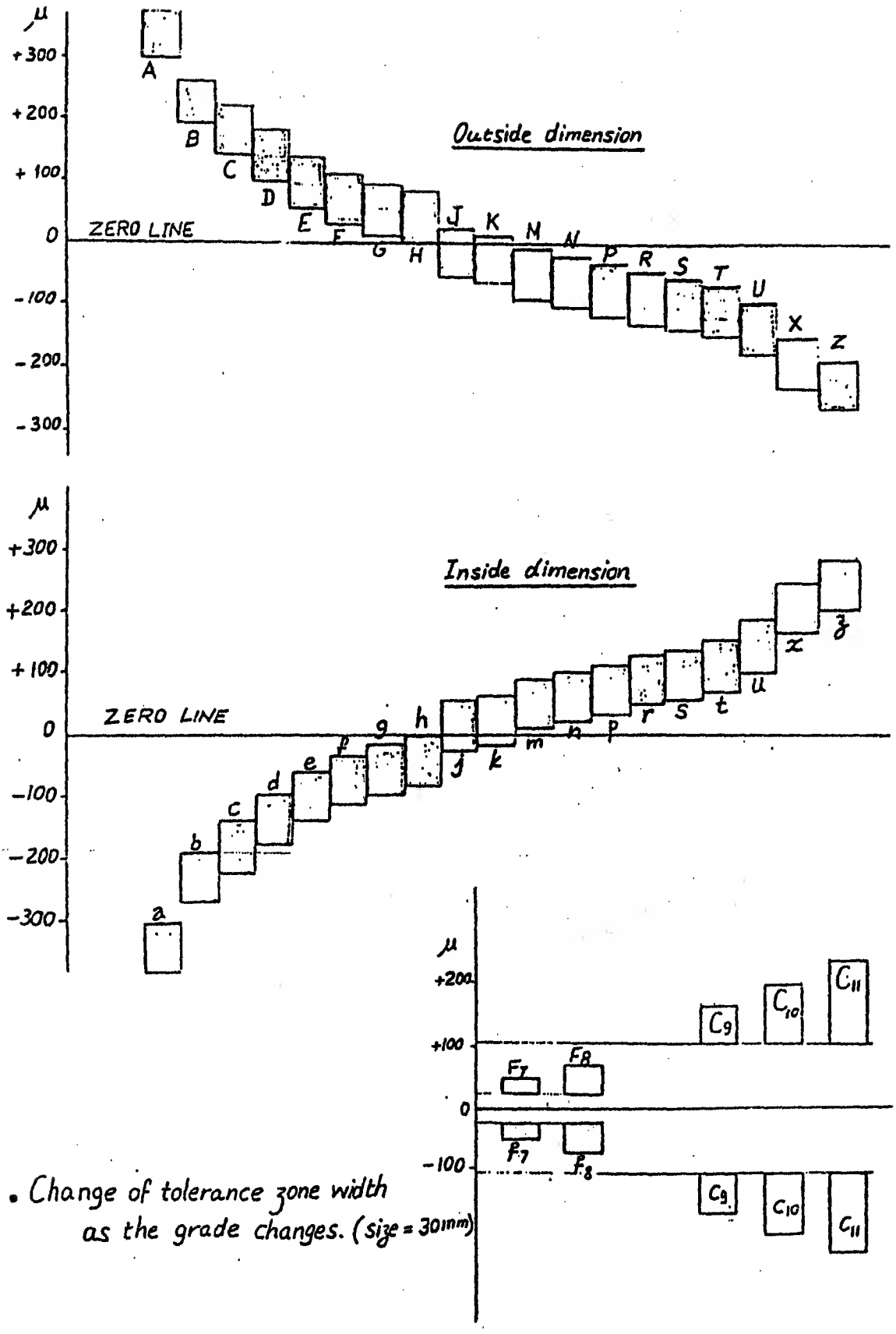
D = Geometric mean diameter for each range in mm

IT1	to	IT7	used for gauges
IT5	to	IT11	used for general fits
IT9	to	IT14	used for general workshop tolerances
IT12	to	IT16	used for general large tolerances and not for fits.

* An extract from DIN 7150 , 7151

MAXIMUM ROOT MEAN SQUARE(R. M. S.) VALUES OF SURFACE ROUGHNESS CORRESPONDING TO FUNDAMENTAL TOLERANCE GRADES.

PRODUCTION PROCESSES.	TOLERANCE GRADES.	DIAMETER OR LENGTH (MM.)												
		MORE THAN	1	3	6	10	18	30	50	80	120	180	250	315	400
		UP TO	3	6	10	18	30	50	80	120	180	250	315	400	500
MACHINE LAPPING, FINE GRINDING, HIGH QUALITY BORING.	IT 5	0.2			0.4			0.8			R.M.S. = 1.6				
GRINDING, FINE HONING.	IT 6	0.4			0.8			1.6							3.2
HIGH QUALITY TURNING, HONING, BROACHING.	IT 7	0.4			0.8			1.6			3.2				
FINE TURNING, FINE BORING, REAMING.	IT 8	0.8			1.6			3.2				6.3			
TURNING, BORING.	IT 9	1.6			3.2			6.3							12.5
SHAPING, MILLING, ROLLING EXTRUSION.	IT 10	3.2				6.3				12.5					
ROUGH TURNING, DRILLING PRECISION TUBE DRAWING.	IT 11	3.2			6.3			12.5				25			
LIGHT PRESS WORK. TUBE DRAWING	IT 12	6.3				12.5				25					50
GENERAL PRESS WORK, TUBE ROLLING.	IT 13		12.5				25				50				
DIE CASTING.	IT 14	12.5			25			50				100			



• Change of tolerance zone width as the grade changes. (size = 30mm)

BASIC HOLE SYSTEM

H6

Diameters		HOLE	SHAFT												
			Running fit				Slide fit	Push fit	Wringing fit	Drive fit	Medium force fit	FORCE fit			
From	to	H6	e7	f6	g5	h5	js5	k5	m5	n5	p5	r5	s5	t5	u5
1	3	+ 7 0	-14 -23	- 7 -14	- 3 - 8	0 - 5	+ 4 0	-	+ 7 + 2	+11 + 6	+14 + 9	+17 +12	+ 20 + 15	-	+23 +18
3	6	+ 8 0	-20 -32	-10 -18	- 4 - 9	0 - 5	+ 4 - 1	-	+ 9 + 4	+13 - 8	+17 +12	+20 +15	+ 24 + 19	-	+28 +23
6 6	10	+ 9 0	-25 -40	-13 -22	- 5 -11	0 - 6	+ 4 - 2	+ 7 + 1	+12 + 6	+16 +10	+13 +15	+25 +19	+ 29 + 23	-	+34 +28
10	14	+11	-32	-16	- 6	0	+ 5	+ 9	+15	+20	+26 +18	+31 +23	+ 36 + 28	- -	+41 +33
14	18	0	-50	-27	-14	- 8	- 3	+ 1	+ 7	+12	+26 +18	+31 +23	+ 36 + 28	- -	+41 +33
18	24	+13	-40	-20	- 7	0	+ 5	+11	+17	+24	+31	+37	+ 44	-	+ 50 + 41
24	30	0	-61	-33	-16	- 9	- 4	+ 2	+ 8	+15	+22	+28	+ 35	+ 50 + 41	+ 57 + 48
30	40	+16	-50	-25	- 9	0	+ 6	+13	+20	+28	+37	+45	+ 54	+ 59 + 41	+ 71 + 60
40	50	0	-75	-41	-20	-11	- 5	- 2	+ 9	+17	+22	+34	+ 43	+ 65 + 54	+ 81 + 70
50	65	+19	-60	-30	-10	0	+ 6	+15	+24	+33	+44	+54 +41	+ 66 + 53	+ 79 + 66	+100 + 87
65	80	0	-90	-49	-23	-13	- 7	+ 2	+11	+20	+32	+56 +43	+ 72 + 59	+ 88 + 75	+115 +102
80	100	+22	-72	-36	-12	0	+ 6	+18	+28	+38	+52	+66 +51	+ 86 + 71	+106 + 91	+139 +124
100	120	0	-107	-58	-27	-15	- 9	- 3	+13	+23	+37	+69 +53	+ 94 + 79	+119 +104	+159 +144

BASIC HOLE SYSTEM

H6

Diameters		HOLE	SHAFT												
			Running fit				Slide fit	Push fit	Wringing fit	Drive fit	Medium force fit	Force fit			
From	to	H6	e7	f6	g5	h5	j5	k5	m5	n5	p5	r5	s5	t5	u5
120	140	+25	- 85	-43	-14	0	+ 7	+21	+33	+45	+61	+ 81 + 63	+110 + 92	+140 +122	+188 +170
140	160	0	-125	-68	-32	-18	-11	+ 3	+15	+27	+43	+ 83 + 65	+118 +100	+152 +134	+208 +180
160	180											+ 86 + 68	+126 +108	+164 +146	+228 +210
180	200	+29	-100	-50	-15	0	+ 7	+24	+37	+51	+70	+ 97 + 77	+142 +122	+186 +166	+266 +236
200	225	0	-146	-79	-35	-20	+13	+ 4	+17	+31	+50	+100 + 80	+150 +130	+200 +180	+278 +259
225	250											+104 + 84	+160 +140	+216 +196	+304 +284
250	280	+32	-110	-56	-17	0	+ 7	+27	+43	+57	+79	+117 + 94	+181 +158	+241 +218	+338 +315
280	315	0	-162	-88	-40	-23	+16	+ 4	+20	+34	+56	+121 + 98	+193 +170	+263 +240	+373 +350
315	355	+36	-125	-62	-18	0	+ 7	+29	+46	+62	+87	+133 +108	+215 +190	+293 +268	+415 +390
355	400	0	-180	-96	-43	-25	-18	+ 4	+21	+37	+62	+139 +114	+233 +208	+319 +294	+360 +435
400	450	+40	-135	-68	-20	0	+ 7	+32	+50	+67	+95	+153 +126	+259 +232	+357 +330	+517 +490
450	500	0	-198	-188	-47	-27	-20	+ 5	+23	+40	+68	+159 +132	+279 +252	+387 +360	+567 +540

BASIC HOLE SYSTEM
H7

Diameters		HOLE	SHAFT									
			Running fit									
From	to	H7	a9	b9	b8	c9	c8	d9	d8	e8	f7	g6
1	3	+ 9 0	- 270 - 295	-140 -165	-140 -154	- 60 - 85	- 60 - 74	- 20 - 45	- 20 - 34	- 14 - 28	- 7 - 16	- 3 -10
3	6	+12 0	- 270 - 300	-140 -170	-140 -158	- 70 -100	- 70 - 88	- 30 - 60	- 30 - 48	- 20 - 38	- 10 - 22	- 4 -12
6	10	+15 0	- 180 - 316	-150 -186	-150 -172	- 80 -116	- 80 -102	- 40 - 76	- 40 - 62	- 25 - 47	- 13 - 28	- 5 -14
10	14	+18	- 290	-150	-150	- 95	- 92	- 50	- 50	- 32	- 16	- 6
14	18	0	- 333	-193	-177	-138	-122	- 93	- 77	- 59	- 34	-17
18	24	+21	- 300	-160	-160	-110	-110	- 65	- 65	- 40	- 20	- 7
24	30	0	- 352	-212	-193	-162	-143	-117	- 98	- 73	- 41	-20
30	40	+25	- 310 - 372	-170 -232	-170 -209	-120 -182	-120 -159	- 80	- 80	- 50	- 25	- 9
40	50	0	- 320 - 382	-180 -242	-180 -219	-130 -192	-130 -169	-142	-119	- 89	- 50	-25
50	65	+30	- 340 - 414	-190 -264	-190 -236	-140 -214	-140 -185	-100	-100	- 60	- 30	-10
65	80	0	- 360 - 434	-200 -274	-200 -246	-150 -224	-150 -196	-174	-146	-106	- 60	-29
80	100	+35	- 380 - 467	-220 -307	-220 -274	-170 -257	-170 -224	-120	-120	- 76	- 36	-12
100	120	0	- 410 - 497	-240 -327	-240 -294	-180 -267	-180 -234	-207	-174	-126	- 71	-34
120	140	+40	- 460 - 560	-260 -360	-260 -323	-200 -300	-200 -263	-145	-145	- 85	- 43	-14
140	160	0	- 520 - 620	-280 -380	-280 -343	-210 -310	-210 -273	-245	-208	-148	- 83	-39
160	180		- 580 - 680	-310 -410	-310 -373	-230 -330	-230 -293					
180	200	+46	- 660 - 775	-340 -455	-340 -412	-240 -355	-240 -312	-170	-170	-100	- 50	-15
200	225	0	- 740 - 855	-380 -495	-380 -452	-260 -332	-260 -332	-285	-242	-172	- 96	-44
225	250		- 820 - 935	-420 -535	-420 -492	-280 -395	-280 -352					
250	280	+52	- 920 -1050	-480 -610	-480 -561	-300 -430	-300 -381	-190	-190	-110	- 56	-17
280	315	0	-1050 -1180	-540 -670	-540 -621	-330 -450	-330 -411	-320	-271	-191	-108	-49
315	355	+57	-1200 -1340	-600 -740	-600 -689	-360 -500	-360 -449	-210	-210	-125	- 62	-18
355	400	0	-1350 -1490	-680 -820	-680 -769	-400 -540	-400 -489	-350	-299	-214	-119	-54
400	450	+63	-1500 -1655	-760 -915	-760 -857	-440 -595	-440 -537	-230	-230	-135	- 68	-20
450	500	0	-1650 -1805	-840 -995	-340 -937	-480 -635	-480 -577	-380	-327	-232	-131	-60

BASIC HOLE SYSTEM (H7)

Diameters		SHAFT									
		Slide fit	Push fit	Wringing fit	Slide fit	Medium force fit	Force fit				
From	to	h6	js6	k6	m6	n6	p6	r6	s6	t6	u6
1	3	0 - 7	+ 6 - 1	–	+ 9 + 2	+13 + 5	+ 16 + 9	+ 19 + 12	+ 22 + 15	–	+ 25 + 18
3	6	0 - 8	+ 7 - 1	–	+12 + 4	+16 + 8	+ 20 + 12	+ 23 + 15	+ 27 + 19	–	+ 31 + 23
6	10	0 - 9	+ 7 - 2	+10 + 1	+15 + 6	+19 +10	+ 24 + 15	+ 28 + 19	+ 32 + 23	–	+ 37 + 28
10	14	0	- 8	+12	+18	+23	+ 29	+ 34 + 23	+ 39 + 28	–	+ 44 + 33
14	18	-11	- 3	+ 1	+ 7	+12	+ 18	+ 34 + 23	+ 39 + 28	–	+ 44 + 33
18	24	0	+ 9	+15	+21	+28	+35	+ 41 + 28	+ 48 + 35	–	+ 54 + 41
24	30	-13	- 4	+ 2	+ 8	+15	+ 22	+ 41 + 28	+ 48 + 35	+ 54 + 41	+ 61 + 48
30	40	0	+11	+18	+25	+33	+ 42	+ 50 + 34	+ 59 + 43	+ 64 + 48	+ 67 + 60
40	50	-16	- 5	+ 2	+ 9	+17	+ 25	+ 50 + 34	+ 59 + 43	+ 70 + 54	+ 86 + 70
50	65	0	+12	+21	+30	+39	+ 51	+ 60 + 41	+ 72 + 53	+ 85 + 66	+106 + 87
65	80	-19	- 7	+ 2	+11	+20	+ 32	+ 62 + 43	+ 78 + 59	+ 34 + 75	+121 +102
80	100	0	+13	+25	+33	+45	+ 59	+ 73 + 51	+ 93 + 71	+113 + 91	+146 +124
100	120	-22	- 9	+ 3	+13	+23	+ 37	+ 76 + 54	+101 + 79	+126 +104	+166 +144
120	140	0	+14	+28	+40	+52	+ 68	+ 88 + 63	+117 + 92	+147 +122	+195 +170
140	160	-25	-11	+ 3	+15	+27	+ 43	+ 90 + 65	+125 +100	+159 +134	+215 +190
160	180							+ 93 + 68	+133 +108	+171 +146	+525 +210
180	200	0	+16	+33	+46	+60	+ 79	+106 + 77	+151 +122	+195 +166	+265 +236
200	225	-29	-13	+ 4	+17	+31	+ 50	+109 + 80	+159 +130	+209 +180	+287 +258
225	250							+113 + 84	+169 +140	+225 +190	+313 +284
250	280	0	+16	+36	+52	+66	+88	+126 + 94	+190 +158	+250 +218	+347 +315
280	315	-32	-16	+ 4	+20	+34	+ 56	+130 + 98	+202 +170	+272 +240	+382 +350
315	355	0	+18	+40	+57	+73	+ 98	+144 +108	+226 +190	+304 +268	+226 +390
355	400	-36	-18	+ 4	+21	+37	+ 62	+150 +114	+244 +208	+330 +294	+471 +435
400	450	0	+20	+45	+63	+80	+108	+166 +126	+272 +252	+370 +330	+530 +490
450	500	-40	-20	+ 5	+23	+40	+ 68	+172 +132	+292 +252	+400 +360	+580 +540

BASIC HOLE SYSTEM H8

Diameters		Hole	SHAFT													
			Running fit			Slide fit		Push fit	Wringing fit	Drive fit	Medium force fit	Force fit				
From	to	H8	d10	e9	f8	h6	h7	j7	k7	m7	n7	p7	r7	s7	t7	u7
1	3	+14 0	- 20 - 60	- 14 - 39	- 7 - 21	0 -14	0 - 9	+ 7 - 2	- 0 - 0	- 0 + 2	+15 + 6	+18 + 9	+ 21 + 12	+ 54 + 15	-	+ 27 + 18
3	6	+18 0	- 30 - 78	- 20 - 50	- 10 - 28	0 -18	0 -12	+ 9 - 3	-	-	+20 + 8	+24 +12	+ 27 + 15	+ 31 + 19	-	+ 35 + 23
6	10	+22 0	- 40 - 98	- 25 - 61	- 13 - 35	0 -22	0 -15	+10 - 5	+16 + 1	+21 + 6	+25 +10	+30 +15	+ 34 + 19	+ 38 + 23	-	+ 43 + 28
10	14	+27 0	- 50 -120	- 32 - 75	- 16 - 43	0 -27	0 -18	+12 - 6	+19 + 1	+25 + 7	+30 +12	+36 +18	+ 41 + 23	+ 46 + 28	-	+ 51 + 33
14	18												+ 41 + 23	+ 46 + 28	-	+ 51 + 33
18	24	+33 0	- 65 -149	- 40 - 92	- 20 - 53	0 -33	0 -21	+13 - 8	+23 + 2	+29 + 8	+36 +15	+43 +22	+ 49 + 28	+ 56 + 35	-	+ 62 + 41
24	30												+ 49 + 28	+ 56 + 35	+ 62 + 41	+ 75 + 48
30	40	+39 0	- 80 -180	- 50 -112	- 25 - 64	0 -39	0 -25	+15 -10	+27 + 2	+34 + 9	+42 +17	+51 +26	+ 59 + 34	+ 68 + 43	+ 75 + 48	+ 85 + 60
40	50												+ 59 + 34	+ 68 + 43	+ 79 + 54	+ 95 + 70
50	65	+46 0	-100 -220	- 60 -134	- 30 - 76	0 -46	0 -30	+18 -12	+32 + 2	+41 +11	+50 +20	+62 +32	+ 71 + 41	+ 83 + 53	+ 96 + 66	+117 + 87
65	80												+ 73 + 43	+ 89 + 59	+105 + 75	+132 +102
80	100	+54 0	-120 -260	- 72 -159	- 36 - 90	0 -54	0 -36	+20 -15	+38 + 3	+48 +13	+58 +23	+72 +37	+ 86 + 51	+106 + 71	+126 + 91	+159 +124
100	120												+ 89 + 54	+114 + 79	+139 +104	+179 +144
120	140	+63 0	-145 -305	- 85 -185	- 43 -106	0 -63	0 -40	+22 -18	+43 + 3	+55 +15	+67 +27	+83 +43	+103 + 63	+132 + 92	+162 +122	+210 +170
140	160												+105 + 65	+140 +100	+174 +134	+230 +190
160	180												+108 + 68	+148 +108	+186 +146	+250 +210
180	200	+72 0	-170 -335	-100 -215	- 50 -122	0 -72	0 -46	+25 -21	+50 + 4	+67 +17	+77 +31	+96 +50	+123 + 77	+168 +122	+212 +166	+282 +236
200	225												+126 + 80	+176 +130	+226 +180	+304 +258
225	250												+130 + 84	+186 +140	+242 +196	+330 +284
250	280	+81 0	-190 -400	-110 -240	- 56 -137	0 -81	0 -52	+26 -26	+56 + 4	+72 +20	+86 +34	+108 +56	+146 + 94	+210 +258	+270 +218	+367 +315
280	200												+150 + 98	+222 +170	+292 +240	+402 +350
345	355	+89 0	-210 -440	-125 -265	- 62 -151	0 -89	0 -57	+29 -28	+61 + 4	+78 +21	+94 +37	+119 +62	+165 +108	+247 +190	+325 +268	+447 +390
355	400												+171 +114	+265 +208	+351 +294	+492 +435
400	450	+97 0	-230 -485	-135 -290	- 68 -165	0 -97	0 -63	+31 -32	+68 + 5	+86 +23	+103 +40	+131 +68	+189 +126	+295 +232	+393 +330	+553 +490
450	500												+195 +132	+315 +252	+425 +360	+603 +540

BASIC SHAFT SYSTEM
h 6

Diameters		Shaft	HOLE									
			RUNNING FITS									
From	to	h_6	A_9	B_9	B_8	C_9	C_8	D_9	D_8	E_8	F_7	G_7
1	3	0 - 7	+ 295 + 270	+165 +140	+154 +140	+ 85 + 60	+ 74 + 60	+ 45 + 20	+ 34 + 20	+ 28 + 14	+ 16 + 7	+ 12 + 3
3	6	0 8	+ 300 + 270	+170 +140	+158 +140	+100 + 70	+ 88 + 70	+ 60 + 30	+ 48 + 30	+ 38 + 20	+ 22 + 10	+ 16 + 4
6	10	0 - 9	+ 316 + 280	+186 +150	+172 +150	+116 + 80	+102 + 80	+ 76 + 40	+ 62 + 40	+ 47 + 25	+ 28 + 13	+ 2 + 5
10	14	0 -11	+ 333 + 290	+193 +150	+177 +150	+138 + 95	+122 + 95	+ 93 + 50	+ 77 + 50	+ 59 + 32	+ 34 + 16	+ 24 + 6
14	18											
18	24	0 -13	+ 352 + 300	+212 +160	+193 +160	+162 +110	+143 +110	+117 + 65	+ 98 + 65	+ 73 + 40	+ 41 + 20	+ 28 + 7
24	30											
30	40	0	+ 372 + 310	+232 +170	+209 +170	+182 +120	+159 +120	+142	+119	+ 89	+ 50	+ 54
40	50	-16	+ 382 + 320	+242 +180	+219 +180	+192 +130	+169 +130	+ 80	+ 80	+ 50	+ 25	+ 9
50	65	0	+ 414 + 340	+264 +190	+236 +190	+214 +140	+186 +140	+174	+145	+106	+ 60	+ 40
65	80	-19	+ 434 + 360	+274 +200	+246 +200	+224 +150	+196 +150	+100	+100	+ 60	+ 30	+ 10
80	100	0	+ 467 + 380	+307 +220	+274 +220	+257 +170	+224 +170	+207	+174	+126	+ 71	+ 47
100	220	-22	+ 497 + 420	+327 +240	+294 +240	+267 +180	+234 +180	+120	+120	+ 72	+ 36	+ 12
120	140		+ 560 + 460	+360 +260	+323 +260	+300 +200	+263 +200					
140	160	0 -25	+ 620 + 520	+380 +280	+343 +280	+310 +210	+273 +210	+245 +145	+208 +145	+148 + 85	+ 83 + 43	+ 54 + 14
160	180		+ 680 + 580	+410 +310	+373 +310	+330 +230	+293 +230					
180	200		+ 775 + 660	+455 +340	+412 +340	+355 +240	+312 +240					
200	225	0 -29	+ 855 + 740	+495 +380	+452 +380	+375 +260	+332 +260	+285 +170	+242 +170	+170 +100	+ 96 + 50	+ 61 + 15
225	250		+ 935 + 820	+535 +420	+492 +420	+395 +280	+352 +280					
250	280	0	+1050 + 920	+610 +480	+561 +480	+430 +300	+381 +300	+320	+271	+191	+108	+ 69
280	315	-32	+1180 +1050	+670 +540	+621 +540	+460 +330	+411 +330	+190	+190	+110	+ 56	+ 17
315	355	0	+1340 +1200	+740 +600	+689 +600	+500 +360	+449 +360	+350	+299	+214	+119	+ 75
355	400	-36	+1490 +1350	+820 +680	+769 +680	+540 +400	+489 +400	+210	+210	+215	+ 62	+ 18
400	450	0	+1655 +1500	+915 +760	+857 +760	+595 +440	+537 +440	+358	+327	+322	+131	+ 83
450	500	-40	+1805 +1650	+995 +840	+937 +840	+375 +480	+577 +480	+230	+230	+135	+ 68	+ 20

BASIC SHAFT SYSTEM
h 6 (cont.)

Diameters		H O L E									
		Slide fit	Push fit	Wringing fit	Drive fit	Medium force fit	Force fit				
From	to	H7	J7	K7	M7	N7	P7	R7	S7	T7	U7
1	3	+ 9 0	+ 3 - 6	-	0 - 9	- 4 -13	- 7 -16	- 10 - 19	- 13 - 22	-	- 16 - 25
3	6	+12 0	+ 5 - 7	-	0 -12	- 4 -16	- 8 -20	- 11 - 23	- 15 - 27	-	- 19 - 31
6	10	+15 0	+ 8 - 7	+ 5 -10	0 -15	- 4 -19	- 9 -24	- 13 - 28	- 17 - 32	-	- 22 - 37
10 14	14 18	+18 0	+10 - 8	+ 6 -12	0 -18	- 5 -23	-11 -29	- 16 - 34	- 21 - 39	-	- 26 - 44
18 24	24 30	+21 0	+12 - 9	+ 6 -15	0 -21	- 7 -28	-14 -35	- 20 - 41	- 27 - 48	- - 33 - 54	- 33 - 54 - 40 - 61
30 40	40 50	+25 0	+14 -11	+ 7 -18	0 -25	- 8 -33	-17 -42	- 25 - 50	- 34 - 59	- 39 - 64 - 45 - 70	- 51 - 76 - 61 - 86
50 65 80	65 80 100	+30 0 +35	+18 -12 +22	+ 9 -21 +10	0 -30 0	- 9 -39 -10	-21 -51 -24	- 30 - 60 - 32 - 62 - 38	- 42 - 72 - 48 - 78 - 53	- 55 - 85 - 64 - 94 - 78	- 76 -106 - 91 -121 -111
100	120	0	-13	-25	-35	-45	-59	- 73 - 41 - 76	- 93 - 81 -101	-113 - 91 -126	-146 -131 -166
120 140 160	140 160 180	+40 0	+26 -14	+12 -28	0 -40	-12 -52	-28 -68	- 48 - 88 - 50 - 90 - 53 - 93	- 77 -117 - 85 -125 - 93 -133	-107 -147 -119 -159 -131 -171	-155 -195 -175 -215 -195 -235
180 200 225	200 225 250	+46 0	+30 -16	+13 -33	0 -46	-14 -60	-33 -80	- 60 -106 - 63 -109 - 67 -113	-105 -151 -113 -159 -123 -169	-149 -195 -163 -209 -179 -225	-219 -265 -241 -287 -267 -313
250 280 315	280 315 355	+52 0 +57	+36 -10 +39	+16 -36 +17	0 -52 0	-14 -66 -16	-36 -88 -41	- 74 -126 - 78 -130 - 87 -144	-138 -190 -150 -202 -169 -226	-198 -250 -220 -272 -247 -304	-295 -347 -330 -382 -369 -426
355 400 450	400 450 500	0 +63 0	-18 +43 -20	-40 +13 -45	-57 0 -63	-73 -17 -80	-98 -45 -108	- 93 -150 -103 -166 -109 -172	-187 -244 -209 -272 -229 -292	-273 -330 -307 -370 -337 -400	-414 -471 -467 -530 -517 -580

BASIC SHAFT SYSTEM (h 7)

Diameters		Shaft	HOLE									
			Running fit					Slide fit	Push fit	Wringing fit	Drive fit	Medium force fit
From	to	h7	A9	B9	B8	C9	C8	H8	J8	K8	M8	N8
1	3	0 − 9	+ 29 + 27	+165 +140	+154 +140	+ 85 + 60	+ 74 + 60	+17 0	+ 7 − 7	−	−	− 1 −15
3	6	0 −12	+ 30 + 27	+170 +140	+158 +140	+100 + 70	+ 88 + 70	+18 0	+ 9 − 9	−	−	− 2 −20
6	10	0 −15	+ 31 + 28	+186 +150	+172 +150	+116 + 80	+102 + 80	+22 0	+12 −10	+ 6 −10	+ 1 −21	− 3 −25
10	14	0 −18	+ 33 + 29	+193 −150	+177 +150	+138 + 95	+122 + 95	+27 0	+15 −12	+ 8 −19	+ 2 −25	− 3 −30
14	18											
18	24	0 −21	+ 35	+212	+193	+162	+143	+33	+20	+10	+ 4	− 3
24	30		+ 30	+130	+160	+110	+110	0	−13	−23	+29	−36
30	40	0 −25	+ 37 + 31	+232 +170	+209 +170	+182 +120	+159 +120	+39 0	+24 −15	+12 −27	+ 5 −34	− 3 −42
40	50		+ 38 + 32	+242 +180	+219 +180	+192 +130	+169 +130					
50	65	0 −30	+ 41 + 34	+264 +190	+236 +190	+214 +140	+186 +140	+46 0	+28 −18	+14 −32	+ 5 −41	− 4 −50
65	80		+ 43 + 36	+274 +200	+246 +200	+224 +150	+196 +150					
80	100	0 −35	+ 46 + 38	+307 +220	+274 +220	+257 +170	+224 +170	+54 0	+34 −20	+16 −38	+ 6 −48	− 4 −58
100	120		+ 49 + 41	+327 +240	+294 +240	+267 +180	+234 +180					
120	140	0 −40	+ 56 + 45	+360 +260	+323 +260	+300 +200	+263 +200	+63 0	+41 −22	+20 −43	+ 8 −55	− 4 −67
140	160		+ 62 + 52	+380 +280	+343 +280	+310 +210	+273 +210					
160	180		+ 68 + 58	+410 +310	+373 +310	+330 +230	+293 +230					
180	200	0 −46	+ 77 + 66	+455 +340	+412 +340	+355 +240	+312 +240	+72 0	+47 −25	+22 −50	+ 9 −63	− 5 −77
200	225		+ 85 + 74	+495 +380	+452 +380	+375 +260	+332 +260					
225	250		+ 93 + 82	+535 +420	+492 +420	+393 +280	+352 +280					
250	280	0 −52	+105 + 92	+610 +480	+561 +480	+430 +300	+381 +300	+81 0	+55 −26	+25 −56	+ 9 −72	− 5 −86
280	315		+118 +105	+670 +549	+621 +540	+460 +330	+411 +330					
315	355	0 −57	+134 +120	+740 +600	+689 +600	+500 +360	+449 +360	+89 0	+60 −29	+28 −61	+11 −78	− 5 −94
355	400		+149 +135	+820 +680	+769 +680	+540 +400	+489 +400					
400	450	0 −63	+165 +150	+915 +760	+857 +760	+595 +440	+537 +440	+97 0	+66 −31	+29 −68	+11 −86	− 5 −103
450	500		+180 +165	+995 +840	+937 +840	+636 +480	+577 +480					

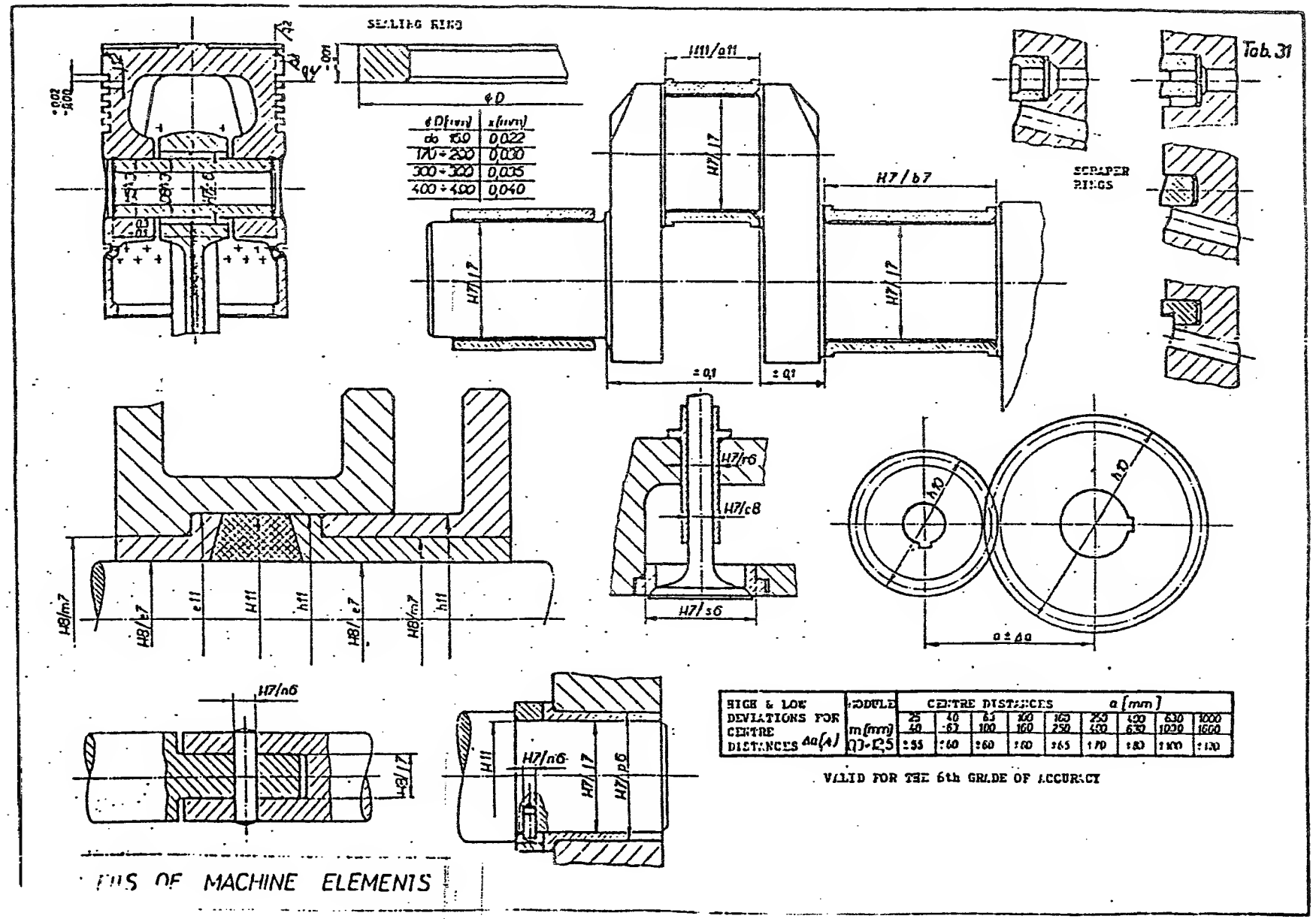
BASIC SHAFT SYSTEM (h8)

Diameters		Shaft	HOLE							
			Running fit							Slide fit
From	to	h8	A9	B9	B8	C9	C8	D10	E9	F8	H8
1	3	0 -14	+ 295 + 270	+165 +140	+154 + 60	+ 85 + 60	+ 74 + 60	+ 60 + 20	+ 39 + 14	+ 21 + 7	+14 0
3	6	0 -18	+ 300 + 270	+170 +140	+158 +140	+100 + 70	+ 88 + 70	+ 78 + 30	+ 50 + 20	+ 28 + 10	+18 0
6	10	0 -22	+ 310 + 280	+186 +150	+172 +150	+116 + 80	+112 + 80	+ 98 + 40	+ 61 + 25	+ 35 + 13	+22 0
10	14	0 -27	+ 333 + 230	+123 +150	+177 +150	+138 + 95	+122 + 95	+120 + 50	+ 75 + 32	+ 43 + 16	+27 0
14	18										
18	24	0 -33	+ 352 + 300	+212 +160	+193 +160	+162 +110	+143 +110	+149 + 65	+ 92 + 40	+ 53 + 20	+33 0
24	30										
30	40	0 -39	+ 372 + 300	+232 +170	+209 +170	+182 +120	+159 +120	+180 + 80	+112 + 50	+ 64 + 25	+39 0
40	50	0	+ 382 + 324	+242 +184	+219 +186	+192 +130	+169 +130				
50	65	0 -46	+ 414 + 340	+264 +190	+236 +190	+214 +140	+186 +140	+220 +100	+134 + 60	+ 76 + 30	+46 0
65	80		+ 434 + 360	+274 +200	+246 +200	+224 +150	+196 +150				
80	100	0 -54	+ 467 + 380	+307 +220	+274 +220	+257 +170	+224 +170	+260 +120	+159 + 72	+ 90 + 36	+54 0
100	120		+ 497 + 410	+327 +240	+294 +240	+267 +180	+234 +180				
120	140	0 -63	+ 560 + 460	+360 +260	+323 +260	+300 +200	+263 +200	+305 +145	+185 + 85	+106 + 43	+63 0
140	160		+ 620 + 520	+380 +280	+343 +280	+310 +210	+270 +210				
160	180		+ 680 + 580	+410 +310	+375 +310	+330 +230	+293 +230				
180	200	0 -72	+ 775 + 660	+455 +340	+412 +340	+355 +240	+312 +240	+355 +170	+215 +100	+122 + 50	+72 0
200	225		+ 855 + 740	+495 +380	+452 +380	+375 +260	+332 +260				
225	250		+ 935 + 820	+535 +420	+492 +420	+395 +280	+352 +280				
250	280	0 -81	+1050 + 920	+610 +480	+561 +480	+431 +300	+381 +300	+400 +190	+240 +110	+137 + 56	+81 0
280	315		+1180 +1050	+670 +540	+621 +540	+460 +330	+411 +330				
315	355	0 -89	+1340 +1200	+740 +660	+689 +660	+500 +360	+449 +360	+440 +210	+265 +125	+151 + 62	+89 0
355	400		+1490 +1350	+820 +680	+769 +680	+540 +400	+489 +400				
400	450	0 -97	+1655 +1500	+915 +750	+857 +760	+595 +440	+537 +440	+480 +230	+290 +135	+165 + 68	+97 0
450	500		+1805 +1650	+995 +840	+937 +840	+635 +480	+577 +480				

BASIC SHAFT SYSTEM

h9 & h11

Diameters		Shaft	HOLE				Shaft	HOLE				
			Running fit					Running fit				
From	to	h9	D10	L9	F8	H8	h11	A11	B11	C11	D11	H11
1	3	0 -25	+ 60 + 20	+ 39 + 14	+ 21 + 7	+14 + 0	0 - 60	+ 330 + 270	+ 200 + 140	+120 + 60	+ 80 + 20	+ 60 0
3	6	0 -30	+ 78 + 30	+ 50 + 20	+ 28 + 10	+18 + 0	0 - 75	+ 345 + 270	+ 215 + 140	+145 + 70	+105 + 30	+ 75 0
6	10	0 -36	+ 98 + 40	+ 61 + 25	+ 35 + 13	+22 0	0 - 90	+ 370 + 280	+ 240 + 150	+170 + 80	+130 + 40	+ 90 0
10	14	0 -43	+120 + 50	+ 75 + 32	+ 43 + 16	+27 0	0 -110	+ 400 + 290	+ 260 + 150	+205 + 95	+160 + 50	+110 0
14	18											
18	24	0 -52	+149 + 65	+ 92 + 40	+ 53 + 20	+33 0	0 -130	+ 430 + 300	+ 290 + 160	+240 +110	+195 + 65	+130 0
24	30											
30	40	0 -62	+180 + 80	+112 + 50	+ 64 + 25	+39 0	0 -160	+ 470 + 310	+ 330 + 170	+280 +120	+240	+160
40	50							+ 480 + 320	+ 340 + 180	+290 +130	+ 80	0
50	65	0 -74	+220 +100	+134 + 60	+ 76 + 30	+46 0	0 -190	+ 530 + 340	+ 380 + 190	+330 +140	+290	+190
65	80							+ 550 + 360	+ 390 + 200	+340 +150	+100	0
80	100	0 -87	+260 +120	+159 + 72	+ 90 + 36	+54 0	0 -220	+ 600 + 380	+ 440 + 220	+390 +170	+340	+220
100	120							+ 630 + 410	+ 460 + 240	+400 +180	+120	0
120	140							+ 710 + 460	+ 510 + 260	+450 +200		
140	160	0 -100	+305 +145	+185 + 85	+106 + 43	+63 0	0 -250	+ 770 + 520	+ 530 + 280	+460 +210	+395 +145	+250 0
160	180							+ 830 + 580	+ 560 + 310	+480 +230		
180	200	0 -115	+355 +170	+215 +100	+122 + 50	+72 0	0 -290	+ 950 + 660	+ 630 + 340	+530 +240		
200	225							+1030 + 740	+ 670 + 380	+550 +260	+460 +170	+290 0
225	250							+1110 + 820	+ 710 + 420	+570 +280		
250	280	0 -130	+400 +190	+240 +110	+137 + 56	+81 0	0 -320	+1240 + 920	+ 800 + 480	+620 +300	+510	+320
280	315							+1370 +1050	+ 860 + 540	+650 +330	+190	0
315	355	0 -140	+440 +210	+265 +125	+151 + 62	+89 0	0 -360	+1560 +1200	+ 965 + 600	+720 +360	+570	+360
355	400							+1710 +1350	+1040 + 680	+760 +400	+210	0
400	450	0 -155	+480 +230	+290 +135	+165 + 68	+97 0	0 -400	+1900 +1500	+1160 + 760	+840 +440	+630	+400
450	500							+2050 +1650	+1240 + 840	+880 +480	+230	0



ELEMENTS OF MACHINE ELEMENTS

Recommended fits

The tolerances for the bore and outside diameters of rolling bearings are internationally standardised,

To achieve an interference or a clearance fit for bearings with cylindrical bore and cylindrical outside diameter, suitable tolerance ranges for the shaft and housing seatings are selected from the ISO tolerance system. Only a limited selection of the ISO tolerance grades need be considered for rolling bearing applications. Fig 2 illustrates the location of the most commonly used grades relative to the bearing bore and outside diameter tolerances.

Bearings with tapered bore are mounted either directly on tapered shaft seatings or on slotted sleeves having an external taper (adapter and withdrawal sleeves); the sleeves are mounted on cylindrical shaft seatings. In these cases, the fit of the inner ring is not determined, as for bearings with cylindrical bore, by the selected shaft tolerance but by the distance through which the ring is driven up on its tapered seating or sleeve. Special precautions with respect to the reduction of the internal clearance must be observed (see introductory text of sections "Self-aligning ball bearings" and "Spherical roller bearings"). If the bearings are to be secured using adapter or withdrawal sleeves, larger diameter tolerances are permitted for the sleeve seating but the tolerances for cylindricity must be reduced (see section "Dimensional, form and running accuracy of bearing seatings and abutments",

Tables 1 and 3 on pages 104, 105, 114 and 115 contain recommendations for suitable shaft and housing fits. These recommendations are based on the general selection guidelines described in the above and are valid for solid steel shafts and cast iron or steel housings. Years of practical experience have shown the recommendations to be correct for a very wide range of applications and bearing arrangements. (housing fits) also gives information as to whether the outer ring can be axially displaced. Using this information it is possible to check that the chosen tolerance is suitable for non-separable bearings which are intended as non-locating bearings.

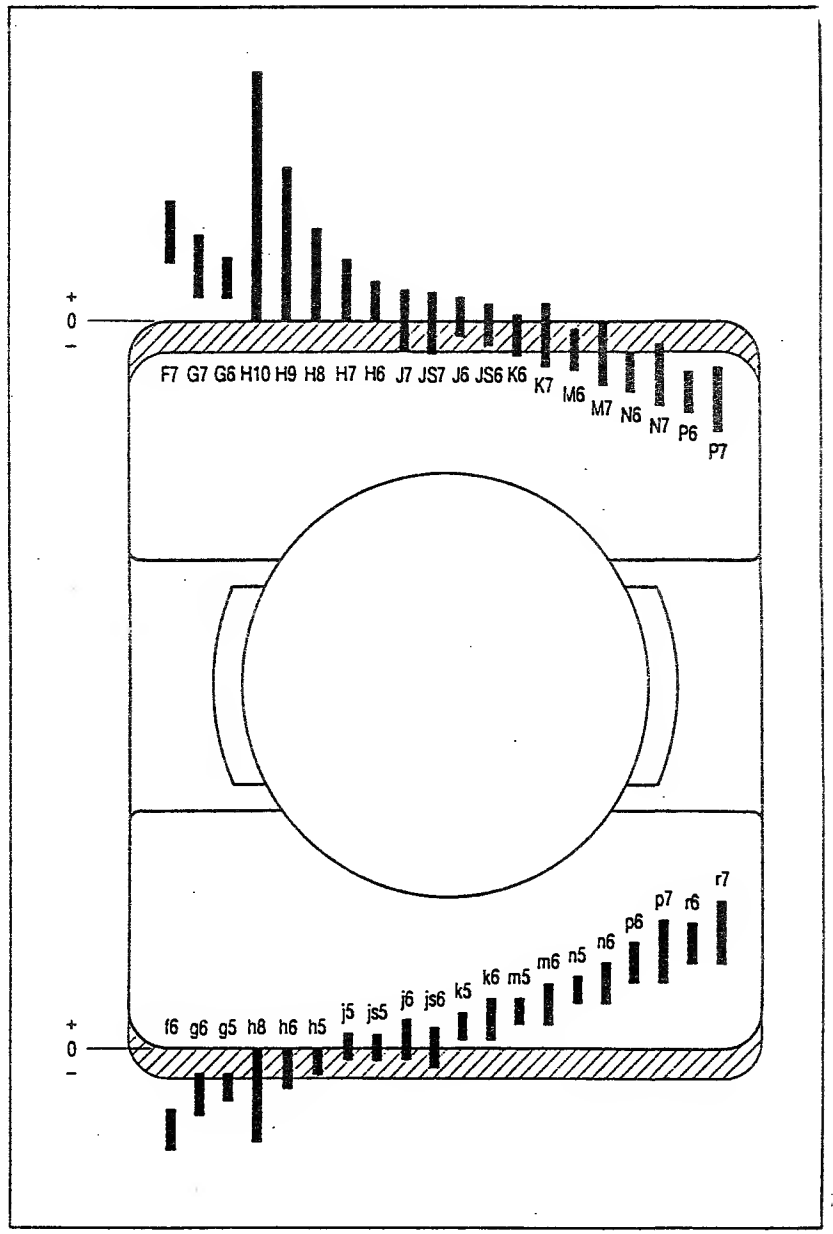
Degree of interference or clearance

- the upper and lower limits of the shaft and housing bore diameter deviations,
- the smallest and largest values of the theoretical interference (+) or clearance (−) in the fit, and
- the smallest and largest values of the probable interference (+) or clearance (−) in the fit.

The deviations of shaft and housing bore are in accordance with ISO/R 286-1962, where appropriate, and with DIN 7160, DIN 7161 and DIN 7172, part 2. Values which differ from these in ISO 286-1:1988 and ISO 286-2:1988 have been included by ISO for experimental use only and have not been considered in the tables.

The normal tolerances for the bore and outside diameter (Δ_{dmp} and Δ_{Dmp}) for which the limiting values have been calculated are also shown in the table and are valid for all metric rolling bearings with the exception of metric taper roller bearings having d ≦ 30 mm and D ≦ 150 mm and thrust bearings with D ≦ 150 mm. The diameter tolerances for these bearings deviate from the normal tolerances for rolling bearings

The probable limits cover 99 % of all combinations of theoretical interference or clearance.



ISO-Allowances

Selection

Allowances in µm = $^1/_{1000}$ mm

Nominal size mm over	to	Exterior Dimensions (Shafts) z 6*	u 6*	u 8¹)	s 6	r 6	p 6*	n 6	k 6	j 6	h 6	h 8*	h 9	h 11	g 6
1	3	+ 32	+ 24	+ 34	+ 20	+ 16	+12	+10	+ 6	+ 4	0	0	0	0	− 2
		+ 26	+ 18	+ 20	+ 14	+ 10	+ 6	+ 4	0	− 2	− 6	−14	− 25	− 60	− 8
3	6	+ 43	+ 31	+ 46	+ 27	+ 23	+20	+16	+ 9	+ 6	0	0	0	0	− 4
		+ 35	+ 23	+ 28	+ 19	+ 15	+12	+ 8	+ 1	− 2	− 8	−18	− 30	− 75	−12
6	10	+ 51	+ 37	+ 56	+ 32	+ 28	+24	+19	+10	+ 7	0	0	0	0	− 5
		+ 42	+ 28	+ 34	+ 23	+ 19	+15	+10	+ 1	− 2	− 9	−22	− 36	− 90	−14
10	14	+ 61		+ 67											
		+ 50	+ 44	+ 40	+ 39	+ 34	+29	+23	+12	+ 8	0	0	0	0	− 6
14	18	+ 71	+ 33	+ 72	+ 28	+ 23	+18	+12	+ 1	− 3	−11	−27	− 43	−110	−17
		+ 60		+ 45											
18	24	+ 86	+ 54	+ 87											
		+ 73	+ 41	+ 54	+ 48	+ 41	+35	+28	+15	+ 9	0	0	0	0	− 7
24	30	+101	+ 61	+ 81	+ 35	+ 28	+22	+15	+ 2	− 4	−13	−33	− 52	−130	−20
		+ 88	+ 48	+ 48											
30	40	+128	+ 76	+ 99											
		+112	+ 60	+ 60	+ 59	+ 50	+42	+33	+18	+11	0	0	0	0	− 9
40	50	−	+ 86	+109	+ 43	+ 34	+26	+17	+ 2	− 5	−16	−39	− 62	−160	−25
		−	+ 70	+ 70											
50	65	−	+106	+133	+ 72	+ 60									
		−	+ 87	+ 87	+ 53	+ 41	+51	+39	+21	+12	0	0	0	0	−10
65	80	−	+121	+148	+ 78	+ 62	+32	+20	+ 2	− 7	−19	−46	+ 74	−190	−29
		−	+102	+102	+ 59	+ 43									
80	100	−	+146	+178	+ 93	+ 73									
		−	+124	+124	+ 71	+ 51	+59	+45	+25	+13	0	0	0	0	−12
100	120	−	+166	+198	+101	+ 76	+37	+23	+ 3	− 9	−22	−54	− 87	−220	−34
		−	+144	+144	+ 79	+ 54									
120	140	−	+195	+233	+117	+ 88									
		−	+170	+170	+ 92	+ 63									
140	160	−	+215	+253	+125	+ 90	+68	+52	+28	+14	0	0	0	0	−14
		−	+190	+190	+100	+ 65	+43	+27	+ 3	−11	−25	−63	−100	−250	−39
160	180	−	+235	+273	+133	+ 93									
		−	+210	+210	+108	+ 68									
180	200	−	+265	+308	+151	+106									
		−	+236	+236	+122	+ 77									
200	225	−	+287	+330	+159	+109	+79	+60	+33	+16	0	0	0	0	−15
		−	+258	+258	+130	+ 80	+50	+31	+ 4	−13	−29	−72	−115	−290	−44
225	250	−	+313	+356	+169	+113									
		−	+284	+284	+140	+ 84									
250	280	−	+347	+396	+190	+126									
		−	+315	+315	+158	+ 94	+88	+66	+36	+16	0	0	0	0	−17
280	315	−	+382	+431	+202	+130	+56	+34	+ 4	−16	−32	−81	−130	−320	−49
		−	+350	+350	+170	+ 98									
315	355	−	+426	+479	+226	+144									
		−	+390	+390	+190	+108	+98	+73	+40	+18	0	0	0	0	−18
355	400	−	+471	+524	+244	+150	+62	+37	+ 4	−18	−36	−89	−140	−360	−54
		−	+435	+435	+208	+114									

Nominal size mm over	to	f 7	f 8*	e 8	e 9*	d 9	c 11	a 11	Internal dimensions (holes) H 7	H 8	H 11	G 7	F 8	E 9	D 10	C 11	A 11
1	3	− 6	− 6	− 14	− 14	− 20	− 60	− 270	+10	+14	+ 60	+12	+ 20	+ 39	+ 60	+120	+ 330
		− 16	− 20	− 28	− 39	− 45	−120	− 330	0	0	0	+ 2	+ 6	+ 14	+ 20	+ 60	+ 270
3	6	− 10	− 10	− 20	− 20	− 30	− 70	− 270	+12	+18	+ 75	+16	+ 28	+ 50	+ 78	+145	+ 345
		− 22	− 28	− 38	− 50	− 60	−145	− 345	0	0	0	+ 4	+ 10	+ 20	+ 30	+ 70	+ 270
6	10	− 13	− 13	− 25	− 25	− 40	− 80	− 280	+15	+22	+ 90	+20	+ 35	+ 61	+ 98	+170	+ 370
		− 28	− 35	− 47	− 61	− 76	−170	− 370	0	0	0	+ 5	+ 13	+ 25	+ 40	+ 80	+ 280
10	14																
		− 16	− 16	− 32	− 32	− 50	− 95	− 290	+18	+27	+110	+24	+ 43	+ 75	+120	+205	+ 400
14	18	− 34	− 43	− 59	− 75	− 93	−205	− 400	0	0	0	+ 6	+ 16	+ 32	+ 50	+ 95	+ 290
18	24																
		− 20	− 20	− 40	− 40	− 65	−110	− 300	+21	+33	+130	+28	+ 53	+ 92	+149	+240	+ 430
24	30	− 41	− 53	− 73	− 92	−117	−240	− 430	0	0	0	+ 7	+ 20	+ 40	+ 65	+110	+ 300
30	40						−120	− 310								+280	+ 470
		− 25	− 25	− 50	− 50	− 80	−280	− 470	+25	+39	+160	+34	+ 64	+112	+180	+120	+ 310
40	50	− 50	− 64	− 89	−112	−142	−130	− 320	0	0	0	+ 9	+ 25	+ 50	+ 80	+290	+ 480
							−290	− 480								+130	+ 320
50	65						−140	− 340								+330	+ 530
		− 30	− 30	− 60	− 60	−100	−330	− 530	+30	+46	+190	+40	+ 76	+134	+220	+140	+ 340
65	80	− 60	− 76	−106	−134	−174	−150	− 360	0	0	0	+10	+ 30	+ 60	+100	+340	+ 550
							−340	− 550								+150	+ 360
80	100						−170	− 380								+390	+ 600
		− 36	− 36	− 72	− 72	−120	−390	− 600	+35	+54	+220	+47	+ 90	+159	+260	+170	+ 380
100	120	− 71	− 90	−126	−159	−207	−180	− 410	0	0	0	+12	+ 36	+ 72	+120	+400	+ 630
							−400	− 630								+180	+ 410
120	140						−200	− 460								+450	+ 710
							−450	− 710								+200	+ 460
140	160	− 43	− 43	− 85	− 85	−145	−210	− 520	+40	+63	+250	+54	+106	+185	+305	+460	+ 770
		− 83	−106	−148	−185	−245	−460	− 770	0	0	0	+14	+ 43	+ 85	+145	+210	+ 520
160	180						−230	− 580								+480	+ 830
							−480	− 830								+230	+ 580
180	200						−240	− 560								+530	+ 950
							−530	− 950								+240	+ 660
200	225	− 50	− 50	−100	−100	−170	−260	− 740	+46	+72	+290	+61	+122	+215	+355	+550	+1030
		− 96	−122	−172	−215	−285	−550	−1030	0	0	0	+15	+ 50	+100	+170	+260	+ 740
225	250						−280	− 820								+570	+1110
							−570	−1110								+280	+ 820
250	280						−300	− 920								+620	+1240
		− 56	− 56	−110	−110	−190	−620	−1240	+52	+81	+320	+69	+137	+240	+400	+300	+ 920
280	315	−108	−137	−191	−240	−320	−330	−1050	0	0	0	+17	+ 56	+110	+190	+650	+1370
							−650	−1370								+330	+1050
315	355						−360	−1200								+720	+1560
		− 52	− 62	−125	−125	−210	−720	−1560	+57	+89	+360	+75	+151	+265	+440	+360	+1200
355	400	−119	−151	−214	−265	−350	−400	−1350	0	0	0	+18	+ 62	+125	+210	+760	+1710
							−760	−1710								+400	+1350

MACHINING INDICATIONS .

(According to I S A Recommendations)*

The surfacing symbols put on the detail and assembly drawings in the drawing office shall in principle specify only the finish of the surface but not the operations required to obtain such finish .

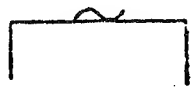
A) WITHOUT MACHINING ALLOWANCE :

1. Surface left rough , without surfacing symbol:

   Surfaces as resulting from the usual non-cutting manufacturing methods as for instance casting , forging , rolling , drawing , pressing ....etc.

2. Rough machined surfaces , sign of approximation:

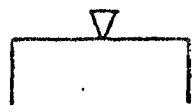
   Surfaces as can be obtained through more careful non-cutting manufacturing methods (fine forged , finely flame cut , smoothed in die). Such surfaces are to be machined only if these demands are not fulfilled.



B) WITH MACHINING ALLOWANCE :

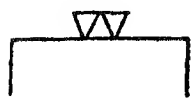
3. Rough machined surfaces , one triangle:

   Surfaces are obtained by one or more rough cutting operations , for instance planing , turning , milling , grinding , boring , filing . Fluttings are perceptible to touch and visible to the naked eye.



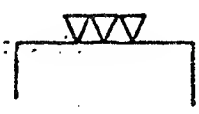
4. Smooth surfaces , two triangles:

   Surfaces are obtained by one or more fine cutting operations , for instance planing , turning , milling , grinding , boring , filing , reaming . Fluttings are still visible to the naked eye.



5. Fine smooth surfaces , three triangles:

   Surfaces are obtained by one or more cutting operations , for instance planing , turning , milling , scraping , reaming . Fluttings are no longer visible to the naked eye.



C) The surfacing symbols alone give no particulars with regard to the size of the machining allowance(material allowance) , or regarding the size of the tolerances .

D) SURFACING SYMBOLS IN CASE OF FITS & TOLERANCES :

The particulars of fits and tolerances are not sufficient to ensure the production of a certain quality of surface . Therefore , the surfacing sign corresponding to the desired quality of surface , or the necessary instructions in words , must be set at the corresponding surface-line. For example with a coarse fit , a ▽ surface finish is to be chosen if that is sufficient for the surface in quistion . But if the survice requires a smoother surface(for instance for a higher sliding speed) a ▽▽ or a ▽▽▽ surfacing symbol must be adopted even with a coarse fit.

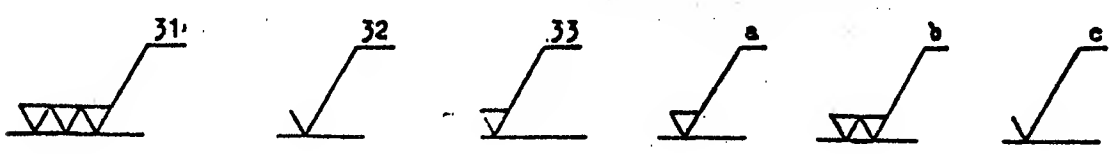
---

* Equivalent to DIN 140 (Oct. 1931).

E) PARTICULARS CONCERNING SPECIAL MACHINING & SPECIAL TREATMENT :

In addition to the surfaces determined by surfacing symbols ~, ▽, ▽▽ & ▽▽▽ further special machining and special treatment is required . These are shown on the drawings either by words and the use of reference hook or by words in conjunction with one of the standard surfacing symbols . e.g.

The words in these particulars may also be replaced by numerals or letters. In these cases it is necessary either to accompany the drawing with a sheet of standards giving particulars of the special treatment or to give a list of them on the drawing.



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DRAWING SHEET STANDARDS.

According to DIN 476 (April , 1939)

Size Code	Dimension mm.
A_0	841 x 1189
A_1	594 x 841
A_2	420 x 594
A_3	297 x 420
A_4	210 x 297
A_5	148 x 210
A_6	105 x 148

****

STANDARD DRAWING SCALES.

According to DIN 823 (Jan. , 1956)

1 : 1 , 1 : 2.5 , 1 : 5 , 1 : 10 , 1 : 20 , 1 : 50 , 1 : 100
1 : 200 , 1 : 500 , 1 : 1000

2 : 1 , 5 : 1 , 10 : 1

****

SURFACE FINISH
Assessment of Roughness

Arithmetical Mean R_a

Mean line of the profile m : Line having the form of the geometrical profile and dividing the effective profile so that, within the sampling length, the sum of the squares of distances ($Y_1, Y_2 \ldots Y_n$) between effective profile points and the mean line is a minimum.

NOTE - The particular case of the mean line of the profile m is the central line, having the same form as the geometrical profile and located parallel to the general direction of the profile within the sampling length, so that the sums of the areas contained between this line and the effective profile, at both sides of this line, are equal.

Arithmetical mean deviation from the mean line of the profile R_a : Average value of the ordinates ($Y_1, Y_2 \ldots Y_n$) from the effective profile to its mean line.

The ordinates are summed without considering their algebraic sign :

$$R_a = \frac{1}{l}\int_0^l |y|\,dx \quad , \qquad \text{approximately} : \qquad R_a = \frac{\sum_1^n |Y_n|}{n}$$

Standard Series of Roughness Numbers

The principal criterion of roughness R_a may be indicated by the corresponding class number shown in the table below

This is to avoid misinterpretation of numerical values which may be indicated in different units, (e.g. micro-metre or micro-inch).

Nominal Values R_a													
	Micrometre	50	25	12.5	6.3	3.2	1.6	0.8	0.4	0.2	0.1	0.05	0.025
	Micro-inch	2000	1000	500	250	125	63	32	16	8	4	2	1
Roughness Number		N 12	N 11	N 10	N 9	N 8	N 7	N 6	N 5	N 4	N 3	N 2	N 1

Sampling Length

Numerical values for l. For measuring roughness, the following series of numerical values of the sampling length l is given.

millimetres	inches	millimetres	inches	millimetres	inches
0.08	0.003	0.8	0.03	8.00	0.30
0.25	0.01	2.50	0.100	25.0	1.00

ISO/TC 57 : R 468 - 1966, ISO/TC 10 : DR 1302 - 1967.

SURFACE FINISH
Typical Applications

Old Surface Finish Symbol	Roughness Numbers			Typical Applications
	No. [1]	Microns [2]	Micro-Inches	
~	N 12	50	2000	Smooth non-machined surfaces with nice appearance · Surfaces with no special requirements but to be touched by the hand.
∇	N 11	25	1000	Non-mating surfaces · Surfaces receiving further machining other than grinding
	N 10	12.5	500	
∇∇	N 9	6.3	250	Surfaces taken as datum for subsequent machining · Surfaces to be finished by grinding · Surfaces bolted to a gasket.
	N 8	3.2	125	Normal mating surfaces with no relative motion, no sealing or contact accuracy.
	N 7	1.6	63	Guiding or centring surfaces with occasional relative motion Low speed bearing (sliding) surfaces · Surfaces finished by scraping to form a metal - to - metal joint
∇∇∇	N 6	0.8	32	Accurate centring surfaces without relative motion - Low speed low pressure bearing surfaces
	N 5	0.4	16	Medium speed (up to 3 m/sec) medium pressure (up to 5 kp/cm^2) bearing surfaces · Sliding surfaces with restricted wear.
	N 4	0.2	8	High-speed heavily-loaded sliding bearings · Interior surfaces of hydraulic cylinders · Centring surfaces of fixtures and chucking cones.
∇∇∇∇	N 3	0.1	4	Ground screw threads and gear teeth · Surfaces for cutting punches.
	N 2	0.05	2	Centring surfaces of high accuracy : main spindles, arbours · Surfaces for cutting dies.
	N 1	0.025	1	Sliding surfaces with extremely low wear · Rolling bearing surfaces · Measuring instruments of high precision.

1) In accordance with ISO DR 1302-1967.
2) Preferred Series of ISO TC/57

SURFACE-ROUGHNESS		
Roughness Ra in µm		Examples of use
basic row	practical row	
0,008 0,010 0,012	0,012	The smoothest functional surfaces which are to exhibit minimum wear at high specific pressures, e.g. the functional surfaces of the most accurate rolling bearings, the measuring surfaces of the most precise gauges.
0,016 0,020 0,025	0,025	Sliding surfaces with high sliding velocity (over 3m/sec.) and with high unit pressure (over 5kg/cm²) the wear of which is to be very small; e. g. sliding surfaces of main bearings, pistons, gudgeon pins, antifriction bearings. Measuring surfaces of exact measuring instruments.
0,032 0,040 0,050	0,05	Centering surfaces of main spindles, arbours and tools of high accuracy; sliding surfaces the wear of which is to be very small.
0,063 0,080 0,100	0,1	Exact sliding surfaces of spindles and shafts that are to be in contact and their clearance is to be very small. Ground threads and tooth faces of gear-wheels.
0,125 0,160 0,200	0,2	Surfaces of chucking cones and tools, centering surfaces of fixtures.
0,25 0,32 0,40	0,4	Sliding surfaces with medium sliding velocity (up to 3m/sec.) and with medium unit pressure (up to 5kg/cm²), the wear of which is to be very small; e.g. sliding surfaces of standard sliding bearings, shifting forks and clutch plates.
0,50 0,63 0,80	0,8	Sliding surface with small sliding velicity and small unit pressure, bearing surfaces for taking up the medium axial pressure. Exact centering surfaces without mutual motion.
1,00 1,25 1,60	1,6	Guiding or centering surfaces with the mutual motion from time to time only. Contin ...

Continuation of the table

basic	practical row	Examples of use
2,00 2,50 3,15	3,2	Contact surfaces without any mutual motion and without high requirements on the tightness and accuracy of contact. Free surfaces (without function) the outer appearance of which is to be nice.
4,0 5,0 6,3	6,3	Rough machined contact surfaces without mutual motion. Free surfaces that are machined for some reason.
8,0 10,0 12,5	12,5	Rough machines contact surfaces without mutual motion. Free surfaces (without function), that are machined for some reason.
16,0 20,0 25,0	25	
31,5 40,0 50,0	50	Smooth non machined surfaces the outer apperarance of which is to be nice or that are taken in hands.
63 80 100	100	
125 160 200	200	Rough non machined surfaces in which no special requirements are placed.
250 315 400	400	
500 630		

ROUGHNESS OF THE SURFACE

Roughness in µm		Methods of machining						Unmachined surfaces	
over	up to	grinding	broaching	turning	milling	boring plan.	manual work.	casting	forging
0,1	0,2	grain	fine	diam	-	-	-	-	-
0,2 0,4	0,4 0,8	under 80	usual	fine	fine cutter	fine	scraping		
0,8 1,6	1,6 3,2	rough	-	usual			filing	accurate (under pressure etc.) into sand	in forging die
3,2 6,3 12,5	6,3 12,5 25			roughing			-		
25 50	50 100	-			-				

MACHINED SURFACES

Method of finishing and properties of machined surfaces

Surface	Method of finish	Properties and examples of use
Rough +) 12,5-25 ▽	By any method of hand working or machining; filing; planing, turning, milling, drilling, grinding, cold drawing through wire-drawing die. The method of machining is determined according to required accuracy, uniformity, kind of connection, appearance and other requirements. Surfaces at which a certain uniformity is required are machined with working allowance. Without working allowance only at cold drawn material.	Machined surfaces with rough touchable and with naked eye clearly visible marks of machine tools (after rough machining with thick chips and great feed). Bearing surfaces which are to bear fully and which need not be accurate in dimensions and smoothness of surface: at bearings, bearing plates, brackets, contact surfaces, which don't move on each other or which are packed with soft packing: at flanges, couplings; surfaces which are not connected with surface of other component parts, e.g. the face of rotating component parts; as at hubs, rims of gears, pulleys; shanks of free-to-go bolts, machined inner free surfaces, holes with great clearance.
Smooth +) 1,6-6,3 ▽		Machined surfaces with marks caused by machine tools visible only very little with the naked eye (e.g. after machining by finishing tools with the small thickness of chips). Surfaces, which are to have fine appearance, free surfaces of shafts, connecting rods, cranks; surfaces which bear against each other accurately and don't move: holes in cranks for shaft and pin, centering areas, friction areas of clutches, surfaces which are in contact with belts, ropes brake bands and brake blocks; sliding surfaces for low speed of slide: at rollers, pistons, rams, seat slide valves, bearings; teeth of gears; surfaces which are bright metal coated.
Very smooth +) 0,1-0,8 ▽	By different way of fine machining or hand working which is determined according to required accuracy, connection, appearance, and other requirements. With working allowance.	Machine surfaces without visible marks caused by machine tools. Surfaces where accuracy, smoothness appearance is required and which are to have low friction and wearing out: Teeth of accurate rears, piston rings, accurate pins, spindles with labyrinth packing, accurate tools, component parts of fine mechanics, contact surfaces which are to pack without packings or which are to be rigidly connected; friction areas with high speed of slide: rollers of high-speed machines; pins; shafts in stuffing boxes etc.

+) there are only orientation values.

NON-MACHINED SURFACES

Method of finishing and properties of non-machined surface.

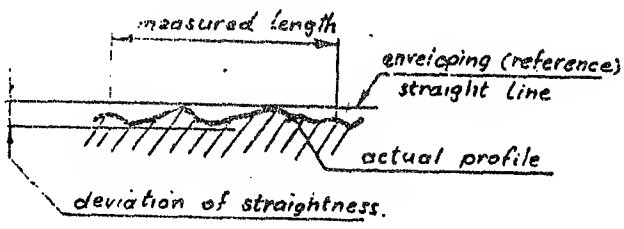
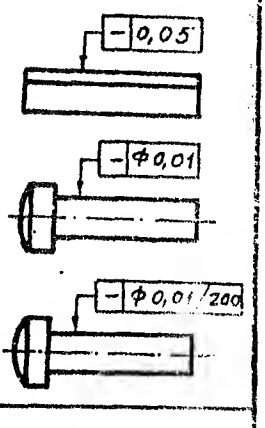
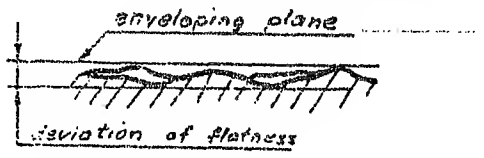
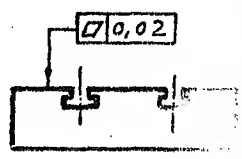
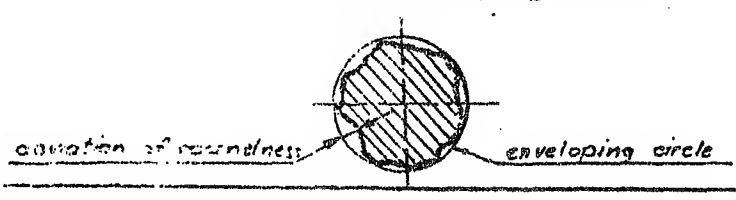
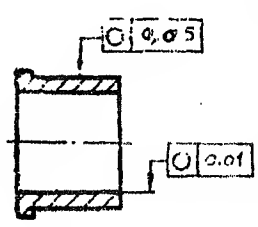
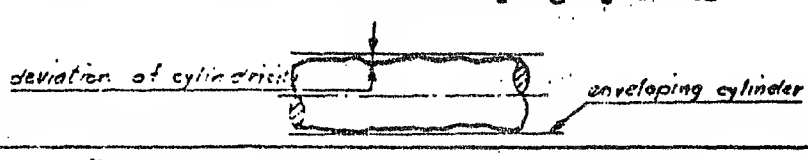
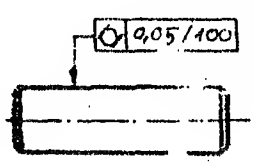
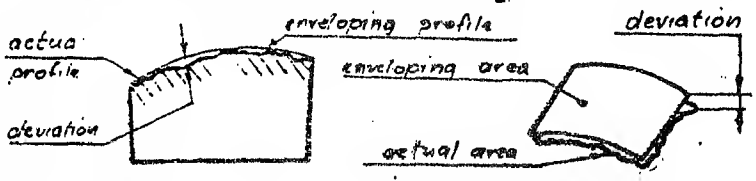
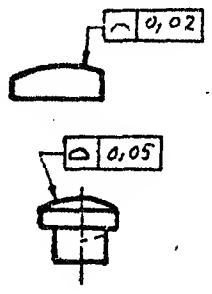
Surface	Method of finish	Properties and examples of use
Rough +) over 100 ∨	The surface of component remains as it has been cast, rolled, pressed. Castings into moulds from common moulding sands. Forgings without use of dies and flat hammers. Without working allowance.	Component surfaces which don't come into contact with surfaces of other components at which the appearance is not important, which need not suit special requirements on smoothness and uniformity and which can be reached by common production, e.g. free surfaces of common castings and forgings for agricultural, brick and mining machines, cranes, bridges; foundation plates for bolts, covered surfaces of frames, stands, etc.
Smooth +) 50-100 ∨	Clean and accurate cast, rolled, forged. Castings cast into fine moulding sand with smooth face, well finished. Forgings forged or die-pressed. Additionally, roughly, as little as possible machined, only in the case when there is necessary to level the surface (by chisel, file, grinding machine)	Non-machined surfaces. Their smoothness is to suit certain requirements (e.g. which are to have nice appearance, or which we hold in our hands), which can be reached by more careful production without any machining: free surfaces of frames, stands, transmission component parts, cut-off devices for pipe lines, hand levers, handles and wheels, inner surfaces of pipes and cut-off devices for pipe lines (to have small resistance). Non-machined surfaces which are additioally and usually hand worked when it was not possible to obtain the required smoothness and uniformity of surface by more careful production without machining; e.g. bearing surfaces of covers, lids, for bolts and nuts on flanges and lugs, casted holes for bolts, surfaces which are dull metal coated (nickle plating, zink coating). Pressed and stamped components, mass produced for motor cars, sewing machines etc.

+) there are only orientation values.

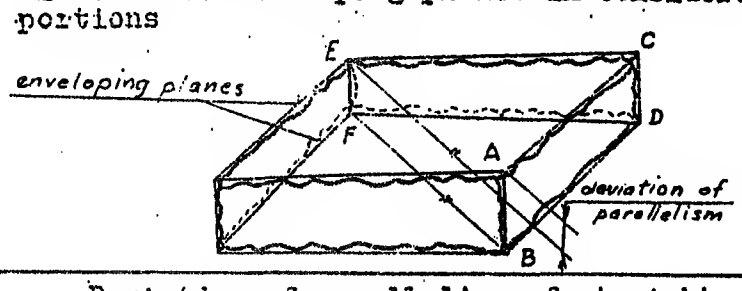
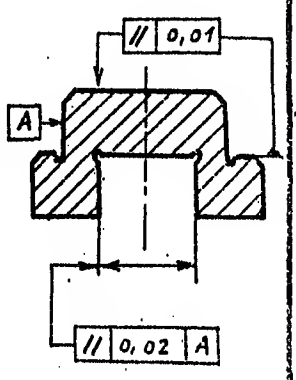
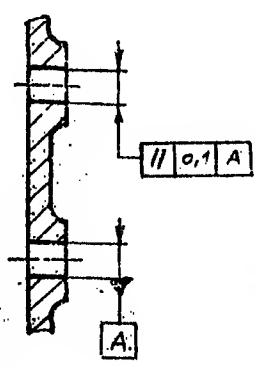
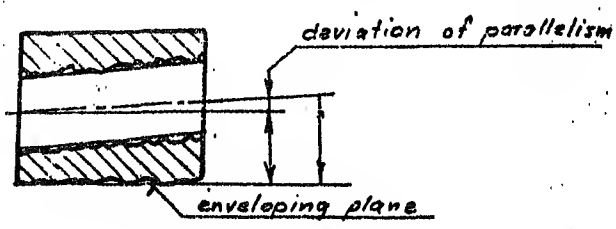
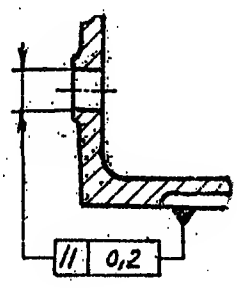
وضع علامات الخشونه على الرسومات الهندسية فى النظم الدولية المختلفة

ألمانيا DIN 4762 R_z (µm)	فرنسا AFNOR Ra (µm)	انجلترا BS1134 Ra (µin)	أمريكا ANSI B46.1 Ra (µin)	الاتحاد السوفيتى GOST 2789/59	تشيكوسلوفاكيا ČSN 0 14450 Ra (µm)	يوغوسلافيا JUS MA0 065	الهند Ra(µm)
R_z=0.05	0.0125	0.5	--	▽14	0.0125	1	R_a0.0125
R_z=0.1	0.025	1	1	▽13	0.025	2	R_a0.025
R_z=0.2	0.05	2	2	▽12	0.05	3	R_a0.05
R_z=0.4	0.1	4	4	▽11	0.1	4	R_a0.1
R_z=0.8	0.2	8	8	▽10	0.2	5	R_a0.2
R_z=1.6	0.4	16	16	▽9	0.4	6	R_a0.4
R_z=3.2	0.8	32	32	▽8	0.8	7	R_a0.8
R_z=6.3	1.6	63	63	▽7	1.6	8	R_a1.6
R_z=12.5	3.2	125	125	▽6	3.2	9	R_a3.2
R_z=25	6.3	250	250	▽5	6.3	10	R_a6.3
R_z=50	12.5	500	500	▽4	12.5	11	R_a12.5
R_z=100	25	1000	1000	▽3	25	12	R_a25
R_z=200	50	2000	2000	▽2	50	13	
R =400	100	—	—	▽1	100	14	—

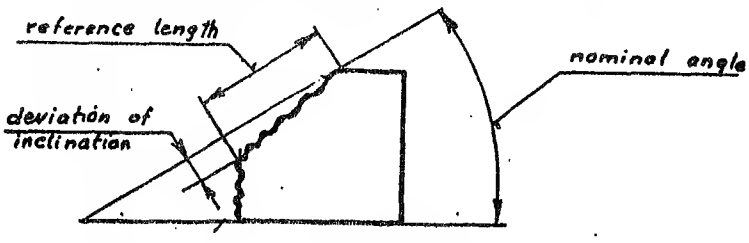
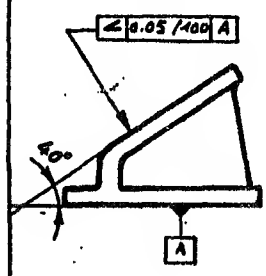
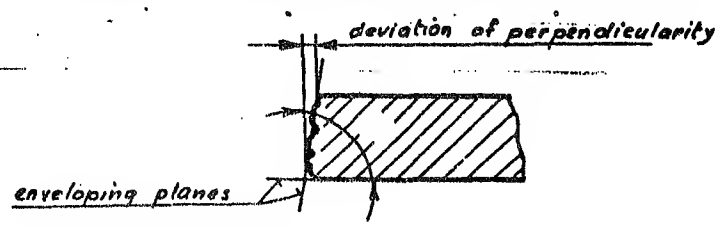
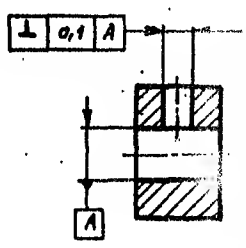
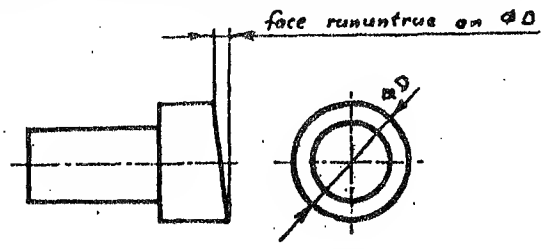
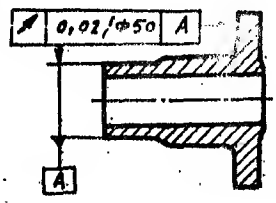
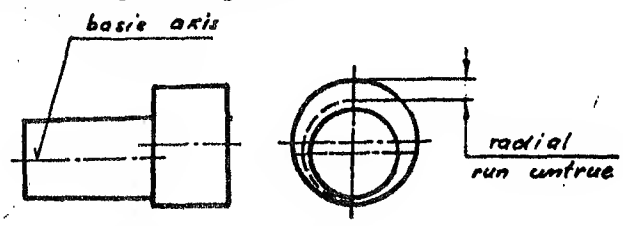
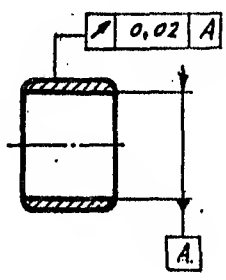
Geometrical Tolerances

Symbol	Definition :	Marking :
—	Deviation of straightness - the maximum measured distance between the actual line or area and enveloping/reference/ line. 	
▱	Deviation of flatness - the maximum measured distance between the actual surface and enveloping /reference/ plane. 	
○	Deviation of roundness - the maximum measured distance between the actual profile and enveloping circle. 	
⌭	Deviation of cylindricity - the maximum measured distance between the actual cylinder and enveloping cylinder 	
⌒ ⌓	Deviation of arbitrary shape profile or area - the maximum measured distance between the actual profile /surface/ and enveloping profile /area/ of ideal shape. 	

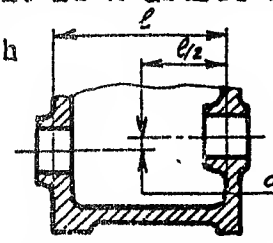
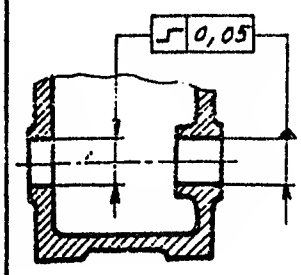
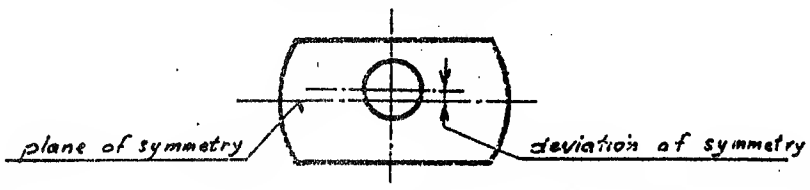
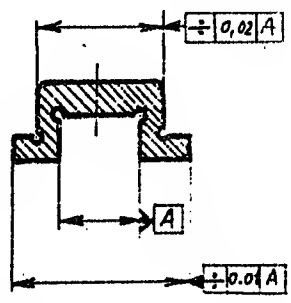
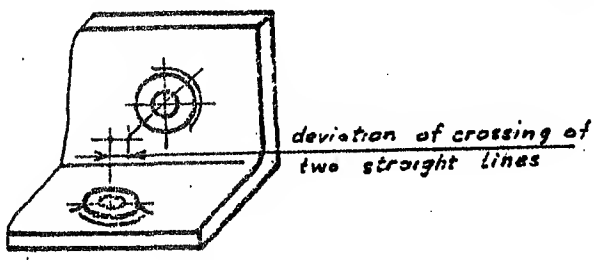
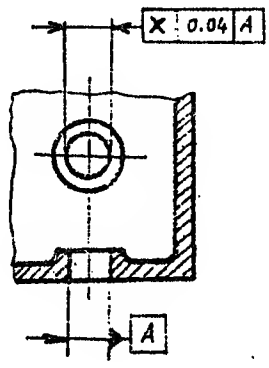
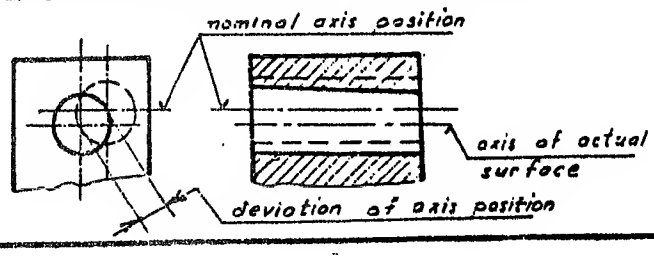
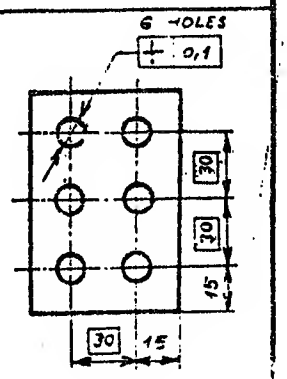
D E V I A T I O N S O F P O S I T I O N :

Symbol	D e v i a t i o n :	M a r k i n g
//	**Deviation of parallelism of planes** - the difference between maximum and minimum distance of enveloping planes in considered portions 	
	Deviation of parallelism of straight lines in the same plane - the difference between maximum and minimum distance of two enveloping straight lines in the same plane in considered portion	
	Deviation of parallelism of straight lines in space - the deviations of projections of considered straight lines in two mutually perpendicular planes, one of which is usually led through one of straight lines and through a chosen point of second straight line.	
	Deviation of parallelism of rotary areas. - the deviation of parallelism of axes of corresponding enveloping areas 	
	Deviation of parallelism of rotary area with flat area - the difference of maximum and minimum distance between enveloping plane and axis of rotary area, in considered portion. 	

DEVIATIONS OF POSITION

Symbol:	Definitions:	Marking:
∠	**Deviation of inclination** – the difference between the actual angle and nominal angle 	
⊥	**Deviation of perpendicularity** – the difference between the actual angle and angle of 90°. 	
↗	**Face / axial / runout / rununtrue /** – the difference between maximum and minimum measured distance of individual points of actual surface from an arbritary basic area perpendicular to the axis of rotation measured on prescribed diameter 	
↗	**Circumferential / radial / rununtrue** – the difference between maximum and minimum measured distance of individual points of actual surface from the basic axis, when rotating the part. 	

DEVIATIONS OF POSITION:

Symbol:	Definitions:	Marking:
⌐¬	**Deviation of concentricity** - the maximum distance between axis of measured surface and axis of basic area /when skew axes it must be determined place or extend of measurement/ if not specified, it is measured in centre of distance between both areas. 	
÷	**Deviation of symmetry** - the distance between planes of symmetry of shape details under consideration 	
X	**Deviation of intersection of straight lines** - the shortest distance of two skew straight lines 	
+	**Deviation of position of axes from nominal position** - the maximum distance of axis/ respectively plane of symmetry/ of actual surface from its nominal position in whole extend of length of checked area 	

GEOMETRICAL DEVIATIONS

Ser.	1	2	3	4	5	6	7	8	9	10	11
Symbol	—	▱	○	⌭	//	⊥	⌐	÷	×	↗	⌰
Definition	Straightness	Flatness	Roundness	Cylindericity	Parallelism	Perpendicularity	Concentricity	Symmetry	Intersection	Circum. Runout	Face Runout